THE "ROMAN ORDNANCE" AT THE SAALBURG.

BY PROF. RUDOLF SCHNEIDER.

For many years the German government has been carrying on a systematic exploration of the ruined fortifications along the line of the Roman military frontier (*linies imperii Romani*), extending from the Danube near Regensburg to the Rhine near Neuwied, a distance of 340 miles. The work received a new impetus a few years ago when the Kaiser ordered the restoration of the best preserved fort, the Saalburg on the Taunus ridge near Frankfurt, in order that it might serve at once as a model of a Roman fortress and as a museum for antique objects of interest discovered in the course of the explorations. In 1904 there were mounted at this re-built Roman fortress three pieces of "Roman ordnance" which fully deserve their post of honor although they are neither Roman nor ancient, and were not found on the old Roman frontier. They are reconstructions made by Major Schramm in accordance with ancient descriptions. They are not mere show pieces but practical engines of war, as appears from the following record of their performances in practical trials.

One of the pieces, the "euthytonon" (Fig. 5) shot a dart about three feet long to a distance of 1,200 feet and drove it through an iron-plated shield more than an inch thick with such force that it projected half its length behind the shield, so that it would have killed or disabled a human shield bearer. Another piece, the "palintonon" (Fig. 4) hurled a stone weighing two pounds to a distance of 600 feet, and a one-pound leaden bullet 1,000 feet. The third piece, the "onager" (Fig. 3), threw a one-pound leaden bullet 460 feet.

These results, which far surpass the achievements of the earliest cannon, are the more surprising because similar experiments, made in 1865, were little better than flat failures, owing chiefly, as Major Schramm has pointed out, to defective construction of the apparatus. About the same time, the Emperor Napoleon III. had some "ancient artillery" constructed, which is still to be seen in the museum at St. Germain. But illness and political cares diverted Napoleon's interest from the subject and no authentic record exists of the performance of these pieces. In order to understand ancient ordnance it is necessary first to get rid of the common and erroneous notion that it consisted, essentially, of huge arbalests or cross-bows. As a matter of fact it was based on a very different principle. The propulsive force of the cross-bow is furnished, chiefly, by the elasticity of the arms of the bow which, bent backward by pulling the cord, spring forward when this is released, carrying with them the cord, which transmits the impulse to the "quarrel," or dart, laid in front of its middle point. The ancient ordnance, on the contrary, had rigid, inelastic arms, moved by the torsional elasticity of bundles of animal sinews which, however, were sometimes replaced by horsehair or even, in protracted sieges, by the long tresses of women. The Roman writers grouped all of these "catapults," as we commonly call them, under the generic name *tormentum*, which means a torsion machine, and applied the names *catapulta*, *ballista*, *scorpio*, etc., to the different varieties rather loosely, and without clear distinction. The tormentum, then, was not a mere improvement of the cross-bow but an entirely new device. Diodorus Siculus ascribes its invention, probably erroneously, to certain eminent mechanical engineers whom Dionysius, in 400 B. C., summoned to Syracuse from all lands to aid him in preparing to make war on Carthage. It is a significant fact that some of these men were Carthaginians, for Pliny speaks of the catapult as a Phœnician invention, and such machines are mentioned in the Old Testament as in use not only in the second century B. C. (I. Macc. 6.51) but even in the eighth century B. C. (II. Chron. 26.15). It seems not unlikely, therefore, that the Greeks merely adopted and perfected an ancient device of Oriental invention.

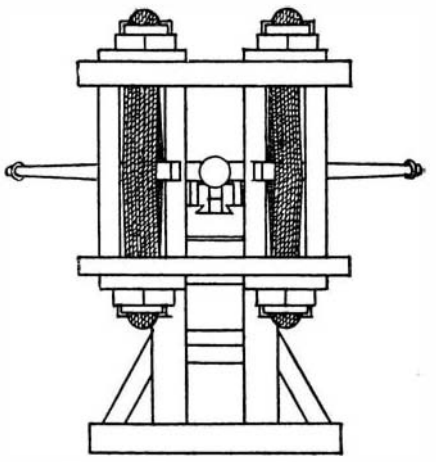

Fig. 2.—Major Schramm's Conception of the Palintonon.

The principle of the tormentum is well illustrated by a common toy, made as follows: Two holes are bored in a half walnut shell, near the edge and opposite each other. A horsehair is threaded through the holes, back and forth, making at each passage a turn around a bit of hair on the outside over each hole, and the ends of the shell, hair are fastened. Then a match stick is thrust through the middle of the multiple loop of horsehair and twisted tightly strands are together. Now, if the stick is withdrawn a little way and suddenly released, its longer end flies around and strikes sharply on the edge of the nutshell, producing a loud sound pleasing to youthful ears.

This plaything, if constructed on a larger scale of stronger materials, with a sling attached to the free end of the stick, would fairly represent the simplest form of tormentum, the onager, or machine sling (Fig. 3). This machine was employed to hurl great stones against walls and towers for the purpose of shattering them or making a breach. The base of the onager is formed of two parallel heavy timbers, joined by cross-pieces at their ends and pierced in the middle by holes through which the bundle of fibers passes, to wrap around pins outside, precisely as in the nutshell snapper. From the center of the bundle of fibers, which tightly fill the holes, rises obliquely a stout wooden arm ending in a hook from which a sling, carrying a stone, is suspended. When this arm is drawn down into a horizontal position by means of a winch, and suddenly released, it springs forward and upward in obedience to the torque of the twisted bundle of sinews until it is stopped by striking against a buffer, whereupon the stone leaves the sling and flies onward toward its goal. Ancient writers use the most extravagant expressions in describing the power of the onager, and it may be inferred that its dimensions greatly exceeded those of the reconstruction at the Saalburg. The same conclusion is suggested by a curious passage, the correct interpretation of which has been reserved for Major Schramm. Ammianus says that the onager was placed on a bed of turf or bricks (that is, on a soft or yielding foundation) because if it were placed on a masonry wall (which is rigid) the wall would be shattered, not by the weight of the machine but by the violent shock (of the recoil). Even in Major Schramm's reconstruction the initial longitudinal tension of the bundle of fibers is twelve tons.

Far more ingenious than this machine sling, though based on the same general principle, are the two other tormenta, each of which has two parallel bundles of torsion fibers and two revolving arms, and resembles a cross-bow in its action, though not in its construction or motive power. In the onager, as we have seen, the torsion fibers are horizontal and the arm moves in a vertical plane. In the palintonon, on the other hand, the fibers as well as the plane of rotation of the arms, which is necessarily perpendicular to the fibers, are sharply inclined, and in the euthytonon the arms move in an almost horizontal plane, while the fibers are nearly vertical. In each of these machines the free ends of the arms are connected by a cord. When the middle of this cord is drawn back the arms, which at first diverge widely, are pulled together and the two bundles of fiber are, consequently, twisted in opposite directions. Then, when the cord is released, the arms spring apart, carrying forward the cord and, before it, the projectile, which proceeds freely on its course when the arms are arrested by the stops.

In the construction of these two-armed catapults Major Schramm followed the descriptions and dimensions given by the Greek writers Hero and Philo, who lived in the third century B. C., and by the Roman Vitruvius, who in the reign of Augustus translated and supplemented their works. Here a difficulty was encountered. The ancient writers distinguished two varieties of tormentum by name without clearly indicating their differences, concerning which diverse opinions have been held by modern commentators. Major Schramm has decided, on both technical and etymological grounds, that the euthytonon was a direct-firing weapon analogous in function to our rifled cannon, while the heavier palintonon was designed, like our mortars, to throw large projectiles over walls and

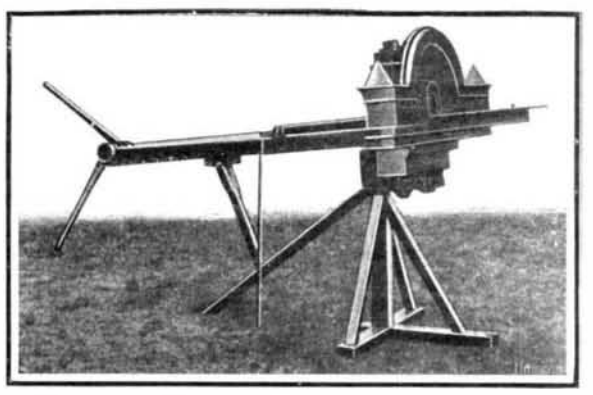

Fig. 5.—Euthytonon, Reconstructed by Major Schramm.

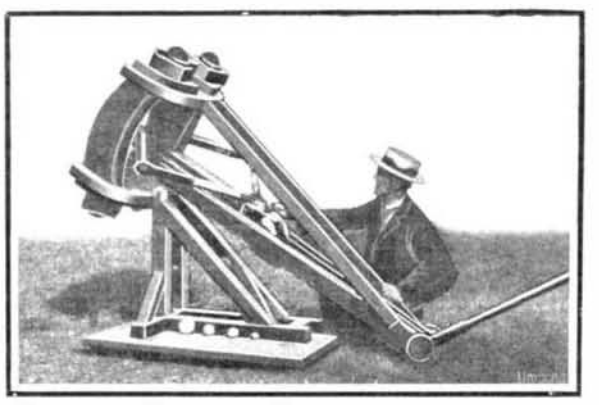

Fig. 4.—Palintonon or Mortar.—Major Schramm's Restoration.

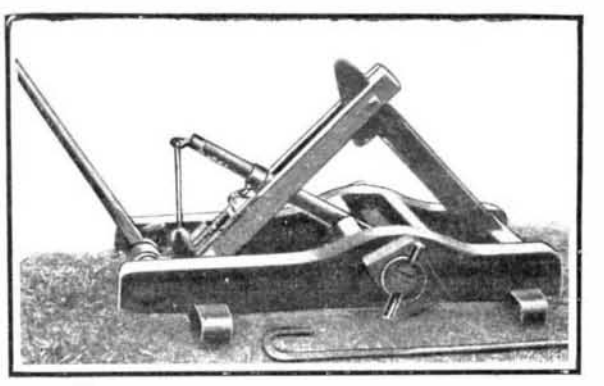

Fig. 3.—The Onager or Machine-Sling, as Restored by Major Schramm.

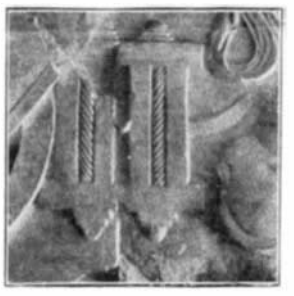

Fig. 7.—Tormentum from Trajan's Column.

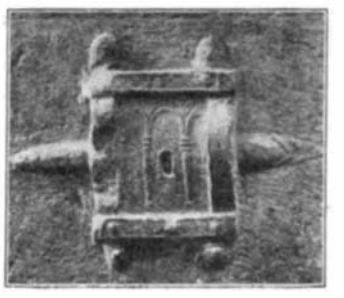

Fig. 6.—Palintonon Carved on the Tombstone of a Roman Artillery Captain.

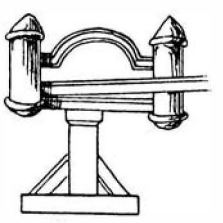

Fig. 8.—Aerotonon or Air Gun from Trajan's Column.

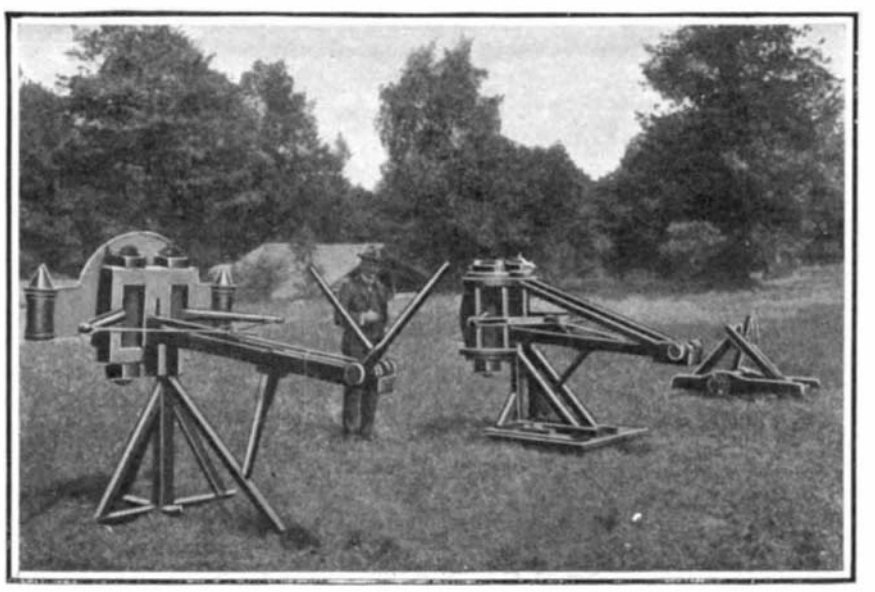

Fig. 1.—Three Roman Pieces of Ordnance (Euthytonon, Palintonon, Onager.)

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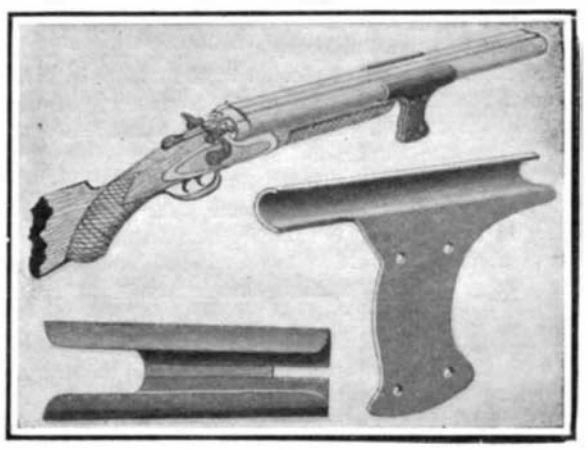
other obstacles. The Saalburg reconstructions were built and mounted in accordance with this view, as is clearly shown by the accompanying illustrations. As each bundle of fibers has an initial tension of twelve tons, these two-armed machines are, in a sense, twice as powerful as the reconstructed onager.

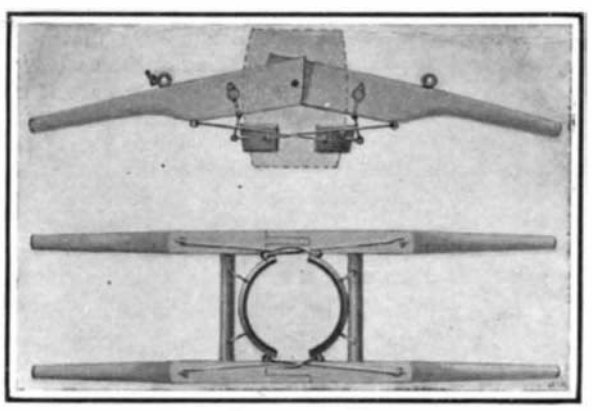
Major Schramm's work has had a very interesting sequel. When pictures of the reconstructed ordnance reached Prof. Hülsen in Rome, they immediately re-



A NOVEL GUN ATTACHMENT.

minded him of a relief carving on a tombstone found there in 1826 and now in the Vatican museum, which had been supposed to represent either a lock or a surveyor's level. The striking resemblance of this relief (Fig. 6) to Schramm's drawing of his palintonon (Fig. 2) proves beyond a doubt that it was intended to represent such a piece of ordnance. This was a very appropriate device, for the tomb was that of a Roman captain of artillery, who served under the emperors Vespasian and Domitian. Similar representations have been found on Trajan's column and on the Pergamon relief, now in Berlin (Fig. 7), but these are far inferior to the one on the tombstone of the Roman officer, which was probably executed, according to the Roman custom, before his death and under his expert supervision.

All three of these Saalburg reconstructions, the onager, the palintonon, and the euthytonon, belong to the class of heavy or siege artillery. The field pieces, light enough to be transported by two mules each,



CARRIER FOR BARRELS.

which were used by Trajan in his German wars and are represented on his column (Fig. 8), were of an entirely different character. They were aerotona, or air-guns, and had levers and compression cylinders of metal.—Abstracted for the Scientific American from an article in Umschau.

IMPROVED CARRIER FOR BARRELS.

A simple device has recently been invented for lifting a barrel, or the like, and carrying it from one place to another. The device is admirably adapted to the use of bricklayers, masons, and other mechanics having to carry barrels of sand, cement, and similar materials. The carrier comprises two pairs of handles which are hinged together, the hinge being so constructed that the handles may freely swing downward, but cannot swing upward above horizontal alinement. The members of each pair are spaced apart by a rung. Suspended from each of the rungs, by means of pins passing therethrough, is a pair of links supporting a segmental band. From the extremities of each band-segment connecting rods extend to the opposite handles. The connection is such that when the handles are swung downward the rings are moved apart, but when they are swung upward the band-segments move toward each other, to clamp any object that may be placed between them. In use the handles are swung downward, and the band-segments are slipped over a barrel. Then, to transport the barrel, it is merely necessary to lift up the handles, when the band-segments will grapple the barrel. As a means for enabling the carrier to be raised to any desired height, rings are attached to the handles, to which hoisting cables or chains may be attached. The inventor of this improved carrier is Mr. John Mitchell, Dannemora, N. Y., Box 135.

A NOVEL GUN ATTACHMENT.

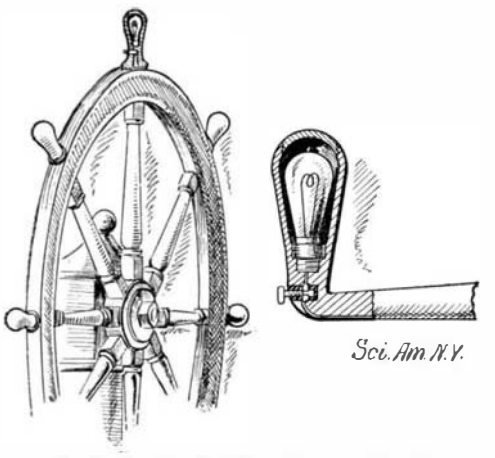
A recent invention provides a handle which may be applied to rifles and shotguns, to facilitate supporting the barrel end of the gun. In aiming a gun in the ordinary way, the palm of the left hand is upward, and in swinging the muzzle of the gun around at different times, the weakest and least used muscles of the arm are employed. Furthermore, the arm is held nearly straight from the wrist to the shoulder, preventing the use of the elbow joint. The improved device gives free use of the elbow joint, and brings into play muscles which are already developed and strengthened, thereby improving the aim of the operator, and relieving him from the fatigue of continually holding his arm in a strained position. The invention also provides a very comfortable and convenient way of carrying the gun, permitting the sportsman to carry it with the muzzle down, and the arm hanging freely at the side. The attachment comprises a clasp adapted to grip the gun barrel, and a depending handle, which projects below the barrel and may be readily grasped by the hand. The clasp consists of two metal plates, curved to embrace the barrel, and formed with depending shanks to which the handle sections are attached. The shanks are separated by a filler piece, and the outer faces of the shanks are covered with wooden sections, the whole being bolted firmly together. In practice the clasp sections may be lined with leather or soft material to prevent scratching the barrels, and if desired the entire handle may be covered with leather to give a proper finish to the same. The clasp may be fixed at any position on the barrel by means of a thumb screw at the forward end, which may be tightened to clamp the clasp sections together. It will be observed that this handle protects the hand from the heated or cold barrel, as well as giving the shooter a firm hold of the gun. Mr. Alfred T. Wight, of Roxton, Texas, has recently received a patent on this gun attachment.

CORN HARVESTER AND HUSKER.

We illustrate in the accompanying engraving a corn harvester and husker invented by Mr. Arthur W. Richards, of Indianola, Iowa. The machine is built to stride two rows of corn. The main body of the machine is carried on large wheels at a height sufficient to clear stalks five feet tall, thus leaving the fodder intact in the field. Inclined spiral reels at the front of the machine are arranged to catch the ears of corn, regardless of their height above the ground. The ears are cut off and fed up to the bed of the machine on an inclined elevator, and are thence carried up with buckets to a table at the top of the machine. A boy at this point slides the ears under a revolving cutter, which cuts off the stem and the curly part of the butt. The ears then pass into the husk shredder. This comprises an upper and lower series of rollers covered with pickers. The lower rollers extend transversely to the upper ones. The ears pass between the sets of rollers, and the husks are shredded off by the pickers. A large fan blows the husks into a screened receptacle. A special feature of the invention is the arrangement of the rollers and pickers. The upper rollers are mounted with sufficient play to allow for ears of different size, and the pickers are longer at the upper end where the corn enters than at the lower end, so that there is no danger of injuring the corn after the husks have been removed.

ODDITIES IN INVENTIONS.

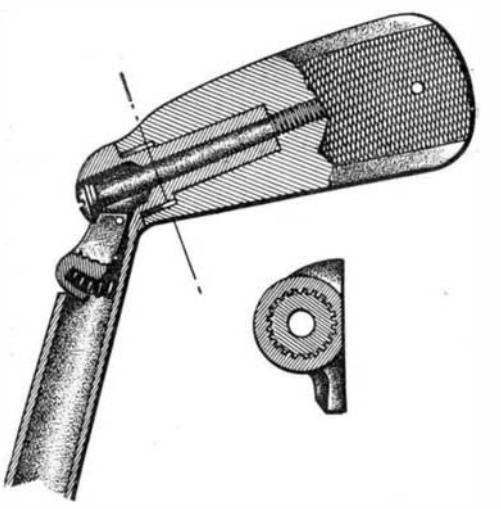
Electrically-Heated Handhold.—In winter weather a motorman's hands are very apt to be numbed by the cold, causing him a great deal of discomfort and also rendering him unable to properly operate the brake and controller handles. The same is true of the pilot of a ship, the chauffeur, or any operator who is exposed to cold. A recent invention provides a very simple remedy for these troubles. The operating handle is made hollow to receive an incandescent electric lamp. At one side is a plug which, on being screwed in, will switch on the current. The heat radiating from the incandescent lamp will warm the handle, giving the motorman a comfortable handhold. As the chamber in the handle is hermetically sealed, all the heat developed by the lamp is given up to the handle, so that the operator is sure of having his hands comfortable, even in the coldest weather. The handhold will also aid in keeping the operator warm, as the palm of the hand is a large nerve center. It is obvious that instead of a lamp, a resistance coil would give equally



ELECTRICALLY-HEATED HANDHOLD.

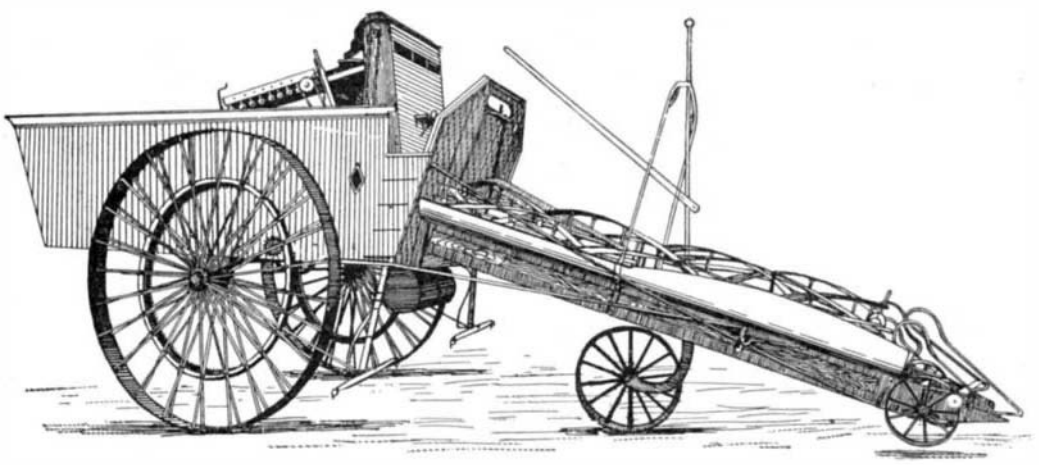
good results. One of the figures in the illustration shows the improved handhold applied to a pilot wheel. In such case the switch or contact plug is located at the hub of the wheel where it serves to control all the lamps at once.

Adjustable Head for Golf Clubs.—Pictured in the accompanying illustration is a golf club provided with an adjustable head which may be set at any desired angle relatively to the shaft, so as to provide in a single club all the different striking faces of a number of clubs. The head of the club is formed of two parts, namely, the socket piece, in which the handle or stick is fixed, and the blade or striking face. The former is formed with a sleeve which extends at an angle into a socket in the blade. Teeth are formed on the sleeve



ADJUSTABLE HEAD FOR GOLF CLUBS.

which mesh with teeth in the socket, as shown in the small detail view, which is a section of the club head, taken along the dot-and-dash line. This toothed engagement of the parts prevents the blade from turning relatively to the sleeve. A bolt passes through the sleeve and is threaded into the body of the blade. The bore of the sleeve at the upper end is widened to admit the head of the bolt. A spring catch is provided at the base of the sleeve which fits under the head of the bolt, drawing the blade snugly onto the sleeve. When it is desired to change the angle of the blade this catch is depressed, releasing the bolt and permitting the blade to be withdrawn sufficiently to clear the teeth on the sleeve. It may then be turned to the desired angle and pressed back onto the sleeve until the catch slips under the bolt head, and makes the blade secure.



CORN HARVESTER AND HUSKER.